South Lodge Pit, Berkshire

[SU 906 819]

Introduction

South Lodge Pit is an abandoned quarry cut into the southern end of the steep river cliff of the west-facing left bank of the river Thames, at Taplow, east of Maidenhead (Figure 4.11). As in the case of Winterbourne Chalk Pit, the site provides an excellent example of a biostratigraphically well-constrained condensed Upper Santonian–Lower Campanian phosphatic chalk succession, with up to 15% P_2O_5, that is comparable in some respects with the more extensive phosphatic chalk sections exposed in abandoned quarries in northern France. A pipe near the middle of the section contains derived, secondarily enriched, phosphatic sand with up to 30% P_2O_5, providing an analogue to the phosphatic sands formerly exploited in northern France and Belgium. Compared with coeval white, non-phosphatic chalks, the phosphatic chalks are extraordinarily rich in fossils, particularly zonally significant crinoids, echinoids and belemnites.

Description

South Lodge Pit is generally known as the 'Taplow Pit' because of its proximity to the village of that name, and lies in private land in the grounds of Taplow Court estate. The quarry formerly exposed two beds of phosphatic chalk in an approximate dip section in a WNW–ESE face about 70 m long (Figure 4.12) and (Figure 4.13). The extensively overgrown section was partially re-excavated in 1999 (Figure 4.14). Two rather inaccessible air-weathered exposures remain, in the same part of the quarry, of the higher of the two phosphatic chalk units and the chalk above. These sections are separated by a Tertiary pipe filled with secondarily enriched phosphatic sand. This pipe has become progressively eroded back and the section seen today is virtually at its back wall. The highest beds of Chalk and the contact with the Palaeogene Reading Beds are rather poorly exposed in the eastern part of the quarry. The strata are variously recorded to dip at 4° or 5° at E10°S (Strahan, 1896); 5°–8° approximately to the south-east (White and Treacher, 1905); and 3° SSE (Hawkins, 1948). Structural contours on the inferred position of the Chalk Rock in the sub-crop (Wilcox, 1953) also suggest a SSE dip.

The description of the lithostratigraphy and biostratigraphy by White and Treacher (1905), and of the petrography of the phosphatic chalks themselves by Strahan (1891, 1895), are still the definitive accounts, although the palaeontological nomenclature needs to be updated. The secondarily enriched phosphatic sand at the base of a post-Chalk pipe was described by de Mercey (1896). An early assessment of the commercial value of the phosphate deposits was made by Strahan (1917) at the time of the First World War. Hawkins (1948) reported analyses of the phosphate content of the phosphatic chalks and assessed their economic potential on the basis of mapping their areal extent; his account includes useful stratigraphical data not available elsewhere. A description of the section, together with a graphic log, was included in a general account of the origin of phosphatic chalks by Willcox (1953), but it is unclear how much of the detail derived from the literature, and how much was original. Jarvis, in an unpublished PhD thesis (1980c), described the section visible in 1979 in considerable sedimentological detail, and later (Jarvis, 1992, fig. 2) plotted his graphic log against the more important phosphatic chalk sections of northern France in a correlation diagram.

Lithostratigraphy

The succession (Figure 4.13), which is about 18 m thick, comprises three units. The lower one consists of white chalk, flinty only at the base of the section, and with a very low content of pelletal phosphate chalk (Figure 4.12). The two higher units of phosphatic chalk have strongly lithified, mineralized hardgrounds and lithified burrowed surfaces at their bases; and each unit passes upwards into less phosphatic white chalk. In the earlier description (White and Treacher, 1905; Willcox, 1953), the lower phosphate-rich parts of the phosphatic chalk units were termed Brown Chalk, the complex succession being simplified to comprise five parts, in ascending order, Division A, Lower White Chalk; Division B, Lower Brown Chalk; Division C, Middle White Chalk; Division D, Upper Brown Chalk; Division E, Upper White Chalk. In this account, a more sedimentological approach is adopted: the two lithified surfaces and their associated phosphatic chalks are here termed the 'Taplow Lower Hardground and Lower Phosphatic Chalk'; and the 'Taplow Upper Hardground and Upper Phosphatic Chalk', respectively. The published thicknesses of individual units differ considerably and there is evidence (e.g. Hawkins, 1948, fig. 5) of lateral variation within the pit and (based on bore-holes) in the immediately surrounding area.

The Lower White Chalk contains a low content of pelletal phosphate and sporadic lightly phosphatized intraclasts. A nodular flint is variously reported 1.5 m (Hawkins, 1948) and 3.6 m (White and Treacher, 1905) below the Lower Hardground. The upper part of the unit is penetrated by phosphatic chalk-filled *Thalassinoides* burrows extending down from the hardground.

The chalkstone of the Taplow Lower Hardground is strongly lithified. The hardground itself is undulating, bored and penetrated by *Thalassinoides* burrows, which pipe the sediment of the Lower Phosphatic Chalk for 2 m into the Lower White Chalk. The surface is covered by adnate organisms such as agglutinating foraminifera, serpulids, *Crania* and bivalves including oysters, *Atreta* and *Spondylus.* Both the hardground and the adnate organisms are heavily encrusted with an irridescent skin of dark brown phosphate, up to 0.03 m thick, which locally caps the open *Thalassinoides* burrows.

The basal 0.15 m of the overlying Lower Phosphatic Chalk were described by White and Treacher (1905) as a sand composed mainly of phosphatized foraminifera, calcite prisms derived from comminuted inoceramid bivalve shell, and fish debris including teeth. This sand contains a variety of types and sizes of mainly phosphatized, and some glauconitized, bivalve-encrusted intraclasts, ripped up from the hardground, including *Micraster* and sponges in pebble preservation. An analysis reported by Hawkins (1948) gave a phosphate content of 15% P_2O_5. The higher part of the phosphatic chalk (*c.* 12% P_2O_5) has the texture of a friable sandstone. Above the lowest 1.8 m, the pelletal phosphate content reduces rapidly upwards over about 0.75 m, and the sediment becomes correspondingly much paler, passing into the Middle White Chalk. Towards the top, closely-spaced *Thalassinoides* burrows pipe brown phosphatic chalk from the Upper Phosphatic Chalk down for up to 2.5 m below the terminal lithified burrowed surface.

The boundary between the Middle White Chalk unit and the Upper Phosphatic Chalk is marked by a weakly lithified and intensely burrowed surface. The combination of closely spaced burrowing, early lithification and fragmentation of the sediment has produced a remarkably complex, nodular texture described by White and Treacher (1905) as a 'pseudo-breccia', and by Jarvis (1980c) as 'pseudo-conglomeratic'. A similar texture was described by Gosselet (1896), from a phosphatic chalk locality in northern France. Traced laterally, the non-phosphatic lithified burrowed surface becomes better defined, and passes laterally into the phosphatized Taplow Upper Hardground. However, compared to the Lower Hardground, the phosphatization is much less strong and there are very few encrusting organisms.

The Upper Phosphatic Chalk is less rich in phosphate than the lower unit, values of 9–13% P_2O_5 being quoted by Hawkins (1948). In addition, the foraminifera are smaller and of higher diversity. The phosphatic chalk grades rapidly upwards into the (relatively inaccessible) Upper White Chalk. The latter unit is soft in the lowest 1.2 m, with a small content of pelletal phosphate; the chalk becomes increasingly 'lumpy' upwards and, in the highest 0.9–1.2 m, near the junction with the Tertiary deposits, intensely indurated, with a subporcellaneous fracture and abundant dendritic MnO_2. It remains to be determined if this induration is wholly a secondary weathering effect, or if it is partly of primary origin. The thickness of 5.4 m of white chalk above the gradational top of the Upper Phosphatic Chalk found in a shaft sunk in the hillside above the pit (Strahan, 1891) suggests that no higher hardground exists at the top of the local succession.

Biostratigraphy

The white chalk below the Taplow Lower Hardground, particularly the top 2.4 m, contains a fauna (White and Treacher, 1905, nomenclature updated) of regular echinoids, for example *Temnocidaris sceptrifera* (Mantell) and *Tylocidaris clavigera* (Mantell) together with irregular echinoids such as *Conulus* sp., *Echinocorys* sp. (fragments only) and *Micraster coranguinum* (Leske). The beds below this yielded few fossils apart from *Inoceramus cuvieri* (i.e. *Platyceramus?).* The phosphate chalk-fill of the *Thalassinoides* burrows extending down from the hardground was reported by Willcox (1953) to contain *Uintacrinus.* White and Treacher (1905) noted that *Micraster* and hexactinellid sponges, including *Coscinopora infundibuliformis* Goldfuss and several species of *Ventriculites* (presumably *Rhizopoterion* spp.), were common both in the chalk immediately below the hardground and in the hardground itself, although the fossils in the latter tended to be preserved as rolled and phosphatized pebbles.

The basal 0.3 m of the Lower Phosphatic Chalk yield common examples of the small belemnite *Actinocamax verus* Miller together with calyx plates and brachials of the zonal index crinoid *Uintacrinus socialis* Grinnell and the brachiopod *Kingena lima* (Defiance), constituting a typical *socialis* Zone association. Sporadic occurrences of *Uintacrinus* are found up to 1.2 m above the base. From about this level, White and Treacher (1905) recorded a single 'slightly ornamented' calyx plate of *Marsupites* (housed in the Natural History Museum, London), which Prof. A.S. Gale (pers. comet., 1999) has identified as belonging to the stratigraphically older morphotype with simple ornament (see p. 68, Chapter 2). In the higher, poorly phosphatic, part of the unit, fossils are very scarce, the only species recorded as 'rather common' being the oyster *Pycnodonte vesiculare* (Lamarck).

The basal, phosphate-rich part of the Upper Phosphatic Chalk contains much inoceramid bivalve shell debris and yields abundant specimens of the belemnite *Gonioteuthis granulata* (Blainville), associated with oysters, including common *Pseudoperna boucheroni* (Woods non Coquand) as well as (largely fragmentary) ornamented calyx plates of *Marsupites testudinarius.* White and Treacher (1905) noted that the *Marsupites* occurred predominantly in the lowest 0.3 m, being rare above that level; the highest record was of a plate with 'blunt radial plication' 2.1 m above the base. The belemnites are so abundant that Willcox (1953) recorded collecting 100 complete specimens from a section 2.1 m high by 4.5 m long, having discarded the fragmentary specimens. Well-preserved, uncrushed tests of *Echinocorys,* of the morphotype characteristic of the higher part of the *Marsupites* zone, stand proud from the weathered face over an interval 0.6–2.1 m above the base.

Willcox (1953) noted the small zonal index echinoid *Offaster pilula* (Lamarck) at 1.8 m above the base of the Upper Phosphatic Chalk, i.e. still within the relatively phosphate-rich part of that unit. He inferred that the *pilula* Zone began at that level, despite the earlier record of a single *Marsupites* plate some 0.3 m higher. This record of *Offaster* is not confirmed by earlier accounts and, indeed, White and Treacher (1905) specifically emphasized that this species was not included in their faunal lists. The overlying beds up to the top of the section yielded relatively few macrofossils apart from inoceramid bivalves, oysters, including *Pseudoperna boucheroni* and *Gryphaeostrea canaliculata* 'var. *striata*' Rowe and incomplete *Gonioteuthis.* Professor Gale (pers. comm.) has additionally collected *Echinocorys scutata depressula* Brydone at this level. The belemnites become very scarce towards the top of the section and are not known from the hard porcellaneous beds.

Interpretation

The occurrence of phosphatic chalk. at Taplow has been known since the 19th century. An interesting account of the history of ideas relating to it is provided by White and Treacher (1905). Whitaker (1889) described it as a grey gritty chalk resembling the (Cenomanian) Totternhoe Stone of the Chiltern Hills (see discussion of this unit under Chinnor Chalk Pit GCR site report), and broadly correlated it on the basis of the belemnites and oysters, with the 'Margate Chalk or Zone of *Marsupites*'. Strahan (1898) appreciated the lenticular nature of the deposit, but had a very unclear idea of its stratigraphical position. Because of the (incorrectly reported) occurrence of *Actinocamax quadratus* (i.e. *Gonioteuthis quadrata* (Blainville)), implying a higher horizon than the *Marsupites* Zone, de Lapparent (1900) actually placed the 'Taplow Chalk' in the Campanian Stage, between the (Santonian) Margate Chalk and the Norwich Chalk. The extremely limited fossil collections made by the [British] Geological Survey, which did not include the critical *Marsupites,* but did include *Conulus* from the base of the section, led to the seriously incorrect interpretation (Jukes-Browne and Hill, 1904) that the Taplow Chalk was a lateral equivalent of *Micraster coranguinum* Zone flinty chalk localities, such as Cliffe and Gravesend in north Kent. It was not until the outstandingly detailed investigation by White and Treacher (1905) that the true stratigraphical position of the deposit was properly appreciated.

The occurrence of *Conulus* places the chalk below the Taplow Lower Hardground broadly within the higher (Santonian) portion of the *coranguinum* Zone. The absence of flint from the top 3.6 m of the succession could be inferred to indicate a level above the equivalent of Whitaker's 3-inch Flint Band (but see further discussion of this point below). The fact that *Conulus* is cited as occurring, rather than common, tends to exclude the normally very fossiliferous highest beds of the *coranguinum* Zone. The Taplow Hardground itself occupies approximately the position of the Barrois' Sponge Bed/Clandon Hardground near the top of the *coranguinum* Zone. However, unlike the situation elsewhere, the hardground at Taplow is overlain by an extremely condensed (1.2 m) *Uintacrinus socialis* Zone in phosphate chalk facies, and there is no evidence of the highly fossiliferous *Conulus*-rich highest part of the *coranguinum* Zone that normally follows the hardground. Hawkins (1948), on the basis of a yellow hard-bed which he found in a nearby pit at Hitcham Park, actually inferred that the Whitway Rock of North Hampshire (i.e. the presumed equivalent of the hardground in question) was probably situated 4.5 m beneath the Taplow Lower Hardground. The occurrence of *Marsupites* at the top of the Lower Phosphatic Chalk, 1.2 m above the basal hardground, indicates unequivocally that the Middle White Chalk belongs to the lower part of the overlying *Marsupites testudinarius* Zone. This is contrary to the uncertainty expressed by White and Treacher (1905) as well as its placing in the *Uintacrinus* Zone by Hawkins (1948).

The Taplow lithified burrowed surface/Upper Hardground appears to be equivalent to the Phosphatic Chalk Hardground at Winterbourne Chalk Pit (see GCR site report, this volume) and, like that hardground, to correlate with the hardgrounds developed below the Brighton Marl in the higher part of the *Marsupites* Zone of the basinal successions (see (Figure 3.89), Chapter 3). The relative abundance of oysters and fragments of inoceramid bivalves in the lower part of the overlying Upper Phosphatic Chalk suggests correlation with the oyster-rich shell-detrital Grobkreide facies. This facies is developed in the higher part of the *Marsupites* Zone, and the basal part of the overlying *pilula* Zone in normal white chalk successions (see also the phosphatic chalk above the Winterbourne Phosphatic Chalk Hardground).

A mean value of 6 for the Riedel Quotient (ratio of alveolar depth to the length of the belemnite) taken from data given by White and Treacher (1905) of the *Gonioteuthis* from the lower part of the beds above the phosphate-rich chalks (i.e. their Upper White Chalk), places the population on the boundary between *G. granulata* (Blainville) and *G. granulataquadrata* (Stoney). This suggests that this interval can be higher, if at all, than the *Marsupites* Zone, and certainly well below even the lower of the two *Offaster* events in basinal chalks. On this basis, the top of the succession does not extend as high as the Upper Hardground at Winterbourne Chalk Pit, unless the latter is reflected by the hard porcellaneous beds near the contact with the Tertiary deposits.

Apart from the fact that the lowest chalk in the section, i.e. below the Taplow Lower Hard ground, contains some pelletal phosphate, the South Lodge Pit provides a classic example, albeit on a minor scale, of a phosphatic chalk succession comparable to those formerly commercially exploited in northern France. Jarvis (1980b, 1992) has given a comprehensive account of the stratigraphy and possible mode of origin of these successions. The phosphatic chalks occupy narrow erosional troughs (cuvettes), up to 1 km in length, 250 m wide and 30 m deep, incised into the white chalk and filled with one or several units of phosphatic chalk separated by non-phosphatic chalk. The cuvettes are floored by a strongly lithified hardground, known as the basal hardground, which is typically glauconitized and heavily phosphatized, and overlain by a pelletal phosphate-rich sediment containing mineralized intraclasts. The hardground truncates the bedding of the underlying chalk and, towards the margins of the cuvette, passes laterally into a mineralized omission surface. Any higher phosphatic chalk units are also situated in erosional troughs, which may themselves be floored by a more or less strongly lithified and mineralized hardground.

The heavily phosphatized Taplow Lower Hardground, which is here tentatively inferred, on biostratigraphical evidence, to correlate with the Barrois' Sponge Bed/Clandon Hardground and, therefore, also with the Paired Hardgrounds of the Winterbourne Chalk Pit, could be taken to represent the basal hardground of a typical, multiple, phosphatic chalk-filled cuvette. However, it is difficult to apply this simple model to the South Lodge Pit succession, in view of the fact that the underlying chalk still contains a not insignificant proportion of pelletal phosphate, and even some weakly phosphatized intraclasts. White and Treacher (1905) noted, on the basis of intervening poor exposures, that there seemed to be a decrease in flint, and a gradual increase in phosphate content of the chalk, as the beds are traced 800 m down-dip in a southerly direction from the flinty coranguinum Zone exposure at the Root-House Pit [SU 9044 8264] to the South Lodge Pit. From this, it follows that the flintless nature of the highest chalk below the Taplow Lower Hardground could reflect some structural control of sedimentation intimately connected with the formation of the overlying packets of phosphatic chalk.

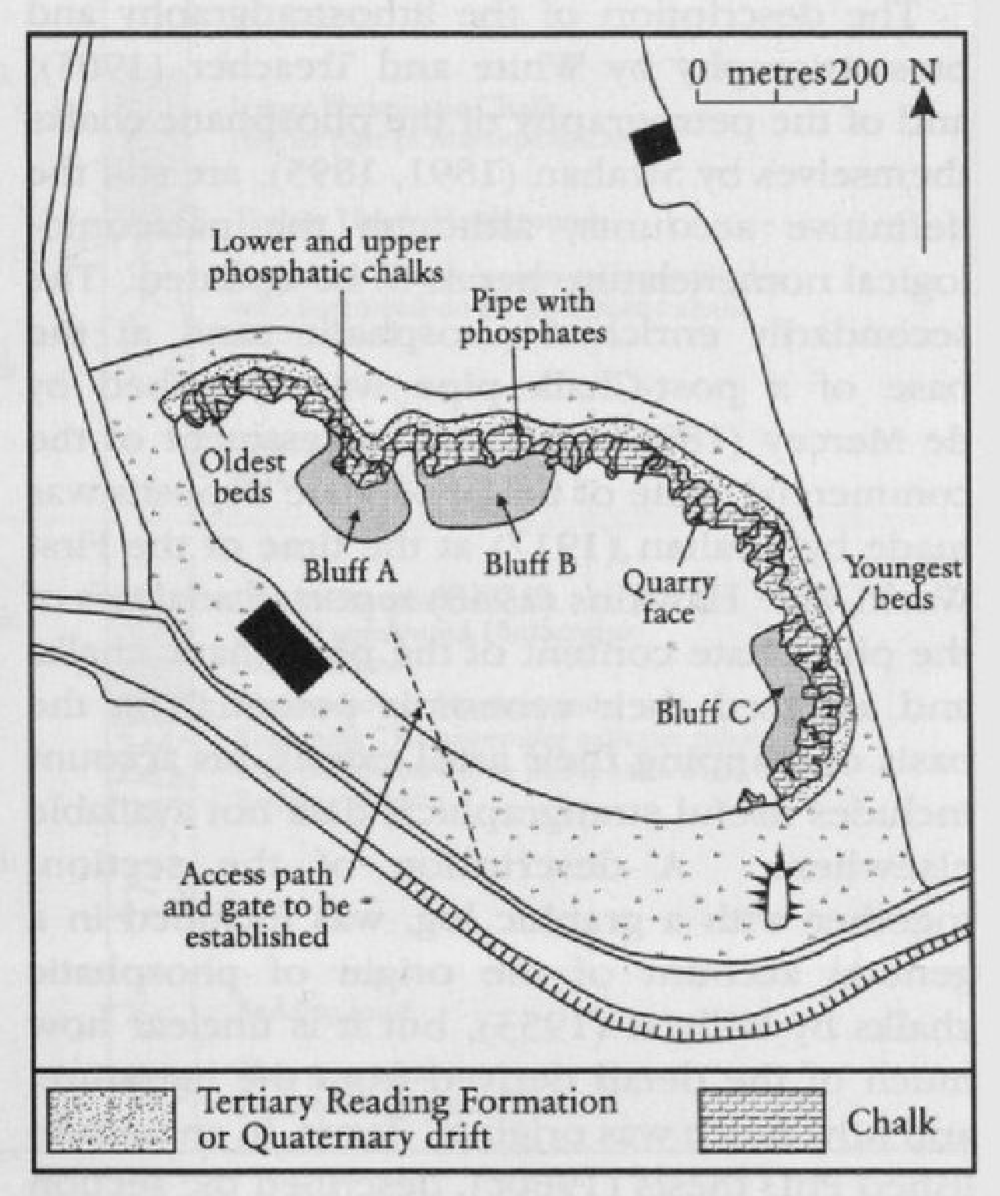
Although White and Treacher (1905) claimed that the Taplow Phosphatic Chalk occupied a tectonically, rather than erosionally induced, synclinal structure, truncated by the Tertiary Reading Beds, their arguments supporting this interpretation are inconclusive. All that the available evidence shows is that there are anomalously high dips at both the South Lodge Pit and the nearby Root-House Pit, with, according to White and Treacher (1905), a change in the dip direction from SSE to south-east. Furthermore, the basal contact of the Reading Beds dips at a lesser angle than the bedding of the Chalk and, outside the immediate area of the phosphatic chalk, appears to rest on various levels within the *coranguinum* Zone. Near Taplow Station, 1 km south-east of the South Lodge Pit, for example, Reading Beds were formerly exposed [SU 913 814] resting on the higher (Santonian) part of the latter zone. If the structural contour map on the inferred top of the Chalk Rock (Willcox, 1953) has any validity, it actually suggests the existence of a weak monoclinal structure near Taplow, rather than a syncline.

White and Treacher (1905) stated that the phosphatic chalk was limited to an area measuring less than 1 mile (1.6 km) from north-west to south-east, and less than 3.5 miles (5.6 km) from north-east to south-west, although they provided no data to substantiate the latter measurement. They noted that the extent of the phosphatic chalk to the south and east of the South Lodge Pit could not be determined due to the cover in those directions of alluvial gravels and Tertiary deposits respectively. To the west the phosphatic chalk occurrence is truncated by the valley of the Thames. However, Hawkins (1948) showed that phosphatic chalk (in part under Drift and Reading Beds cover) could be mapped over an area, 1 km wide near the South Lodge Pit, extending for at least 2.2 km to the northeast, and narrowing to a width of 0.7 km. The size of this area considerably exceeds that of the typical phosphatic chalk cuvette described from northern France.

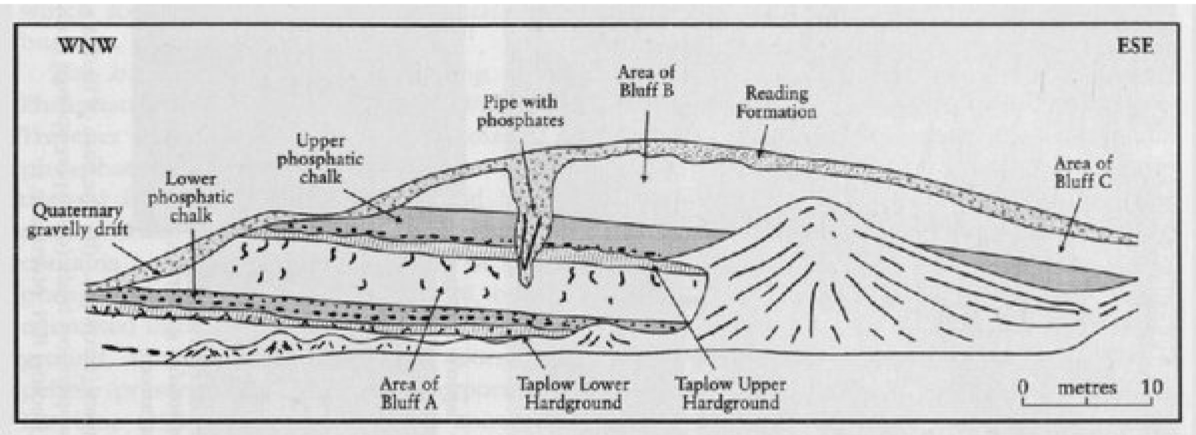
Conclusions

South Lodge Pit exposes one of the few examples of Late Santonian phosphatic chalks in England, comparable to deposits in northern France. The phosphatic deposits and intervening chalks span the latest *M coranguinum* Zone, a highly condensed *Uintacrinus socialis* Zone and the *Marsupites* Zone up to a point probably just below the equivalent of the Friars Bay Marl 1 of the basinal successions of the Southern Province. Mapping of the surrounding area provides a scale for channels in which phosphatic chalks form and indicates the relationship to tectonic structure.

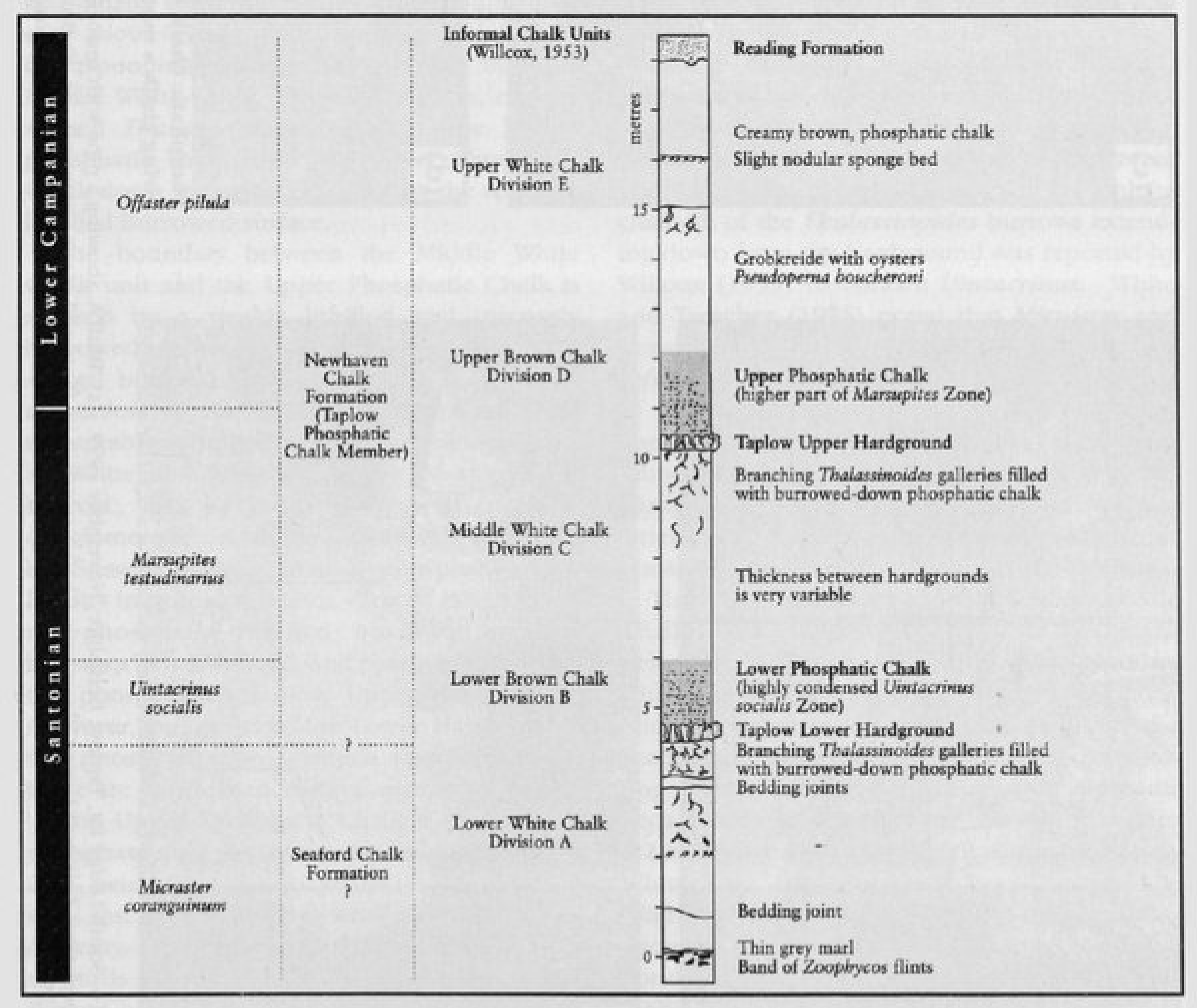
References



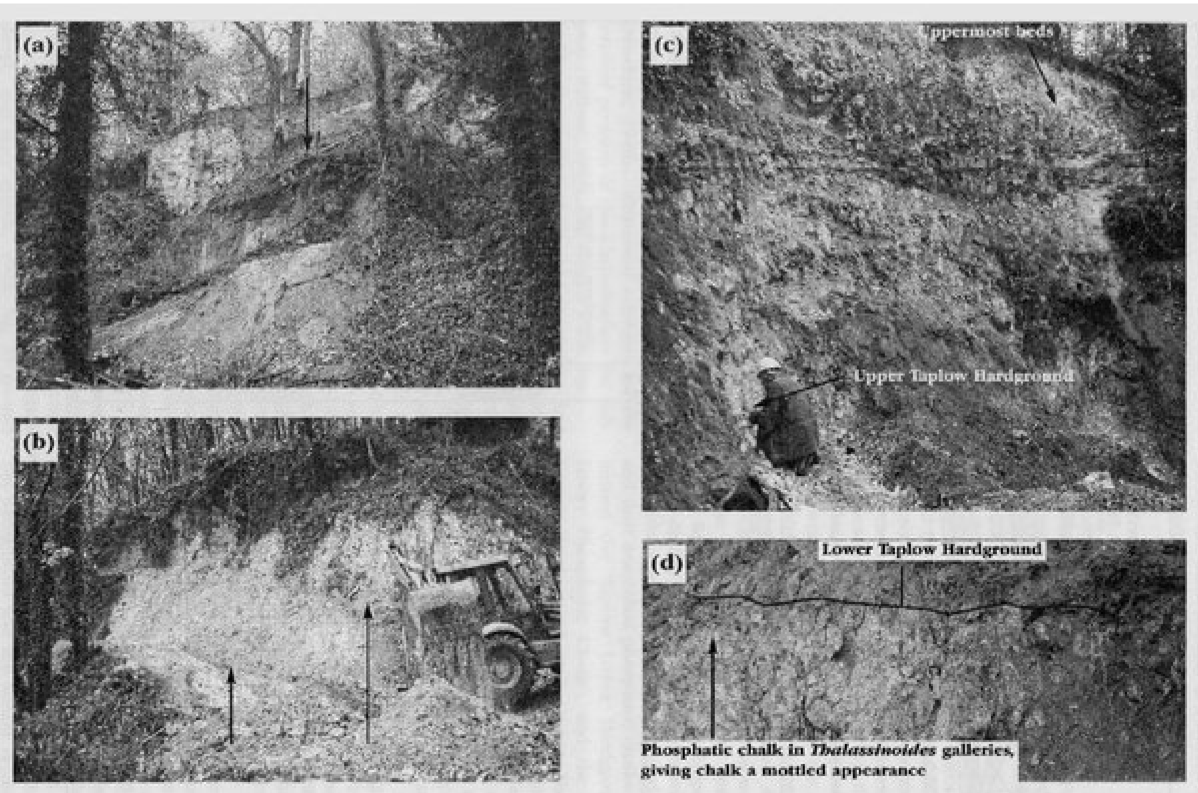
(Figure 4.11) General geology in the vicinity of South Lodge Pit, Taplow.



(Figure 4.12) South Lodge Pit, Taplow, as exposed in 1905. (After White and Treacher, 1905, fig. 1.)

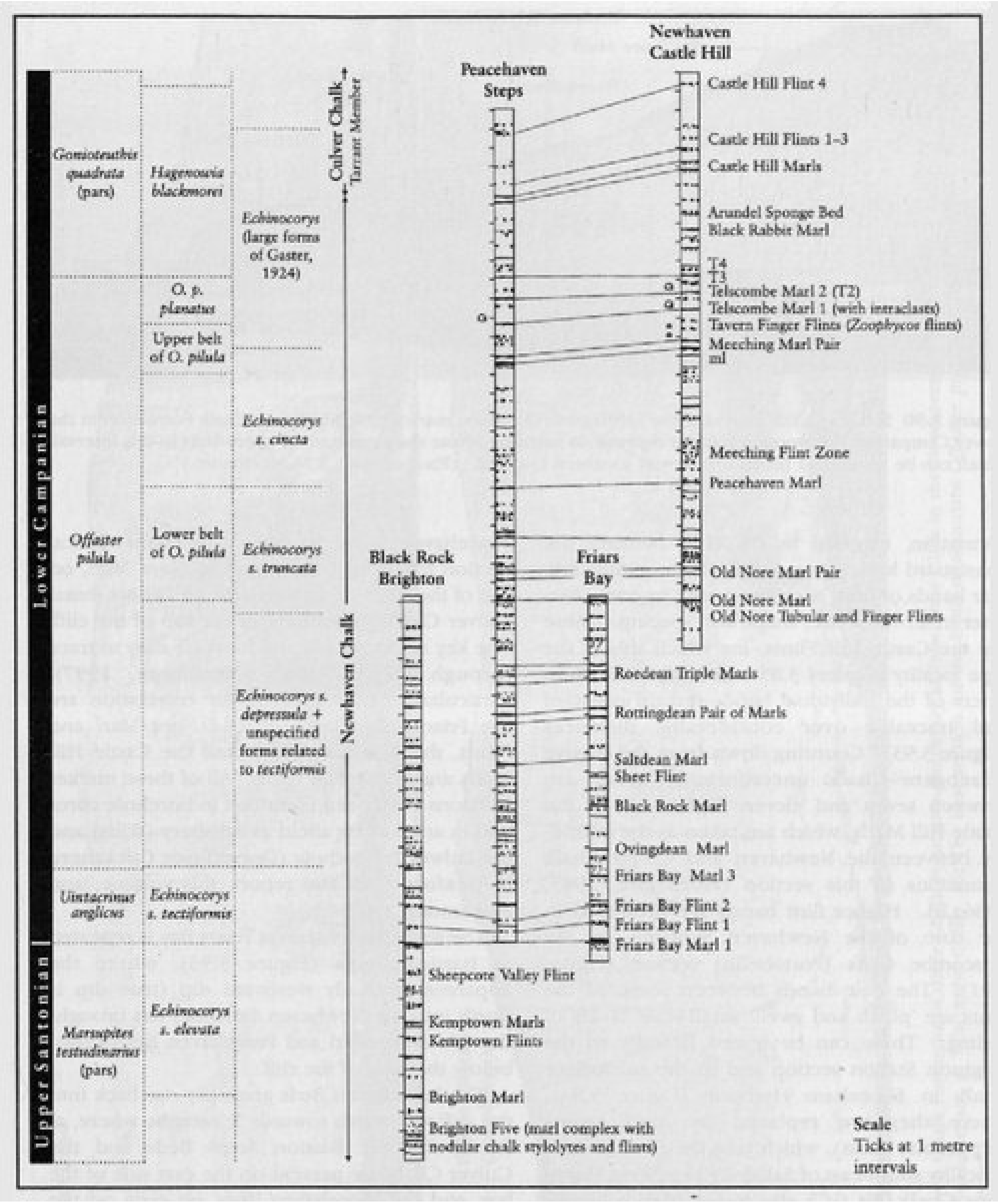


(Figure 4.13) The Chalk succession at South Lodge Pit, Taplow.



(Figure 4.14) South Lodge Pit, Taplow, Berkshire, November 1999. (a) Bluff A, showing a pipe with reworked phosphates (arrowed). (b) The base of Bluff A with Lower Phosphatic Chalk and Upper Phosphatic Chalk underlain by flints and marls (arrowed). (c, d) Bluff C. The uppermost beds (c) display sponge nodular horizons. The Upper (c) and Lower (d)

Taplow Hardgrounds are orange-stained, glauconitized and phosphatized. (Photos: R.N. Mortinore.)



(Figure 3.89) The Newhaven to Brighton coast sections showing the main Upper Cretaceous Chalk sections.